UP-SCALING GROSS PRIMARY PRODUCTION IN A MEDITERRANEAN SAVANNA (DEHESA) ECOSYSTEM USING FIELD SPECTROSCOPY AND RADIATIVE TRANSFER MODELS

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Abstract

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Mediterranean ecosystems constitute a potential â€œhot spotâ€ for assessing impact of climate change; but they are also characterized for a large heterogeneity which complicates the use of remote sensing tools for monitoring carbon fluxes in these particular ecosystems. This is the case of the wooded grasslands or savannas, which combine vegetation types structurally and physiologically very different. We have simulated the estimation of Gross Primary Production (GPP) in a Mediterranean savanna (dehesa) through up-scaling spectral information from leaf/canopy to ecosystem level by using Radiative Transfer Models (RTM). Different predictive models have been tested by simulating Landsat 5 TM and Sentinel-2 spectral bands.

Field works were carried out in Majadas del TiÃ©tar, (CÃ¡ceres, Spain) between May 2009 and April 2011. In the study site grazed grasslands mix up with scattered Holm oaks (tree fraction cover about 20%). Daily GPP and meteorological variables have been measured using Eddy Covariance technique from a flux tower operated by CEAM; moreover, ground spectral data were taken during 20 field campaigns simultaneous to Landsat 5 TM over-passes. In each campaign, an ASD FieldspecÂ® spectroradiometer (ASD inc., Boulder, CO, USA) was used to measure canopy reflectance from 12 grassland plots of 25 m x 25 m and leaf reflectance from up to 10 trees surrounding the flux tower. Current and previous year Holm oak leaves (up to 12 of each type per tree and sampling date) were measured using a plant probe and a leaf clip of the same spectroradiometer. The coupled PROSPECT-5 and SAIL models were used to simulate ecosystem reflectance as a linear combination of the measured grassland and the simulated tree canopy reflectanceâ€™s fraction cover. Simulated reflectance was resampled to the Landsat 5TM and Sentinel-2 spectral bands and was validated using Landsat 5 TM images simultaneously acquired and radiometrically corrected using the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) system. Eventually, three different models based on Vegetation Indices (VI) computed from each sensorÂ´s bands and the Photosynthetically Active Radiation (PAR) measured in the flux tower were used to estimate GPP.

Results show a high agreement between the simulated ecosystem reflectance and the Landsat 5 TM imagery (r2 ranged between 0.94 and 1.00 for the optical bands). GPP models exclusively based on VI showed the least predictive capabilities (r2 â‰¤ 0.36; RRMSE Ð„ [65.00%, 74.29%]).whereas those models where GPP is a linear function of the product VI x PAR achieved larger correlation coefficients (r2 Ð„ [0.74, 0.88] and lower errors (RMSE Ð„ [36.40%, 58.79%]). The most accurate predictions were achieved by models where GPP is a linear combination of a VI that is multiplied by PAR (r2 Ð„ [0.78, 0.88]; RMSE Ð„ [34.83%, 57.30%]). When PAR was included, the model based in the green Normalized Difference Vegetation Index (NDVI) calculated from the Sentinel-2â€™s 4th and 10th bands casted the least reliable estimates (r2 = 0.80; RRMSE = 58.79%). On the contrary, the best predictions were achieved using the NDVI computed from the Sentinel-2â€™s 5th and 6th bands (r2 = 0.88; RRMSE = 34.83%).

We conclude that a wooded grassland ecosystem level reflectance can be simulated from ground hyperspectral measurements using RTM; at least when spectral resolution is degraded to the coarser features of multispectral remote sensors such as Landsat 5 TM. Moreover, daily GPP can be estimated with an acceptable accuracy (RRMSE ~35%) from Sentinel-2 imagery using vegetation spectral indices; however incident PAR must be taken into account. Since the revisit time of this Sentinel-2 over the Mediterranean basin would be lower than 5 or 10 days; Sentinel-2 could largely improve the estimation of GPP in Mediterranean ecosystems, providing acceptable information in terms of temporal and spatial resolution and uncertainty.